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IT-4-P-6044 Energy filtered imaging in a scanning electron microscope

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Electron spectroscopy and spectroscopic imaging in a scanning electron microscope is currently used to separate secondary electrons (SE) and backscattered electrons (BSE) in SEMs. Due to limitations of the energy resolution the underlying spectral information of the emitted SE and BSE remains less investigated and mostly unused for imaging. I this study we will present some results of a retarding field detector with an improved energy resolution.

The ZEISS EsB (Energy selective Backscatter) detector was the first commercially available retarding field detector for a SEM. This detector has a very good surface sensitivity since it can work even at low Voltages. With energy filtered imaging it is possible to enhance material contrast even beyond the usual Z-contrast imaging.

Especially the energy filtering properties for low loss BSE imaging conditions were explored by Jaksch [1] and contrasts were shown which can not be explained with the common BSE contrast mechanism. The material dependent difference of the BSE spectral distributions is utilized here for energy filtered imaging to enhance the contrast between different phases.

In general the spectral distribution for BSE emitted from low Z materials are flat, whereas the spectra of high-Z elements have a pronounced maximum near the elastic peak. This behavior is due to the higher penetration depth and the resulting multiple scattering events of the BSEs. By use of energy windows a gain of contrast can be achieved which is superior to the commonly used Z contrast in conventional BSE imaging [2].

As an example for filtering BSEs we can achieve a strong contrast gain between Y_2O_3 and $MoSi_2$ grains in a SiC matrix, by using only electrons with energy losses up to 100eV from a primary energy of 700V.

Furthermore energy filtered imaging of secondary electrons can enhance contrast for imaging conductors next to less conductive materials. Here the spectra of the secondary electrons are shifted towards each other for the different materials by several eV. As an example the contrast between multilayer graphene and a carbon support film will be presented.

The dependency of the BSE energy loss due to multiple scattering and sample depth can as well be used to gain 3D information from a sample for BSE tomography [3]. The selection of energy windows can be chosen from the elastic peak for pure surface information down to the maximum escape depth of the BSE with maximum energy losses. As an example the different thicknesses of a graphite sample can be imaged by using energy windows of different energy losses.

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